Introduction to Permaculture

Student Workbook

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Introduction to Permaculture
Student Booklet

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In the name of Allah, the Most Gracious, the Most Merciful

Humans everywhere have striven by nature to live a decent life. Allah has endowed man with a mind that distinguishes between good and evil and is capable of creativity, motivating human societies to build systems that help them secure their basic needs and employ nature's resources in a way that serves their interests and the interests of their children in the long term.

It is common sense and sound thinking that human actions should not lead to the destruction and devastation of the resources around them, especially those that are related to their basic needs and sound existence. For example, hunting should be in balanced quantities that suffice people’s needs. They may agree on specific hunting areas or set general rules to prevent hunting during the time of spawning and reproduction so that this does not cause harm to the animals in their surroundings. While this wisdom has become widespread in traditional societies,

we see it absent from humanity in the era of modern industrialization so greed prevailed, corruption appeared, and crops and offspring perished. This prompted some specialists to gather the aspects of this wisdom and the sources and strategies of the rational management of natural resources in a science they called

Permaculture. It is usually translated into Arabic as permaculture or sustainable agriculture.

The name of this science in English consists of two parts: the first- Permanent

The first means permanence and continuity.

Agriculture- It has the meaning of development, multiplication and improvement of the soil and its centrality in resources. These two meanings were combined by the Australian researcher (Bill Mollison) in the late seventies in partnership with David Holmgren as an attempt to create a science that establishes a new relationship with the environment and how to achieve human needs through cooperation rather than competition, and bears responsibility for the safety of others and the environment. This was established by these

people and by the efforts of their students who followed them, such as Geoff Lawton (Jamal al-Din).

Permaculture is a global movement for anyone interested in completing a 72-hour training course to design a sustainable production system (farm or similar) that produces more than it consumes and meets the needs of the user without harming people or the environment. This guide is an attempt to bring this course closer to understanding in a concise and clear way. It provides the reader with appropriate solutions for agriculture in dry areas. We ask God for success, and guidance, and for the reader to understand, memorize and act in a beneficial way.

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Chapter One

Definition-Ethics-Principles

Definition of Permaculture

Permaculture, is defined as an ethical design science based on both diverse scientific knowledge, and on reading and simulating nature and traditional inherited knowledge in the quest to design productive systems, such as farms, the biosphere and the environment for humans from the family level to communities. So that a person can obtain his needs of food, shelter, clothing, etc. It proceeds in an ethical manner that is consistent with the climatic and environmental conditions and the locally available resources, and so that this does not lead to any harm to the environment or to people.

The Three Ethics

The focus of this science on ethics can be understood by looking at its counterparts in other systems of natural resource management.

For example, agricultural systems that rely on chemical pesticides produce food for humans, but they also cause soil pollution and damage to the Earth's ecosystem.

This negatively affects human health by increasing diseases and birth defects due to chemical residues in food, while producers of these harmful substances make huge financial gains at the expense of people and the earth.

In contrast, permaculture science defines the frameworks of reference for sustainable systems through three basic ethics:

1- Caring for the Earth and all the creatures and living systems on it.

2- Caring for people, which includes yourself and others such as family and communities.

3- Fair Share: take, own and consume only what you need and return the surplus to the land or others.

The one who contemplates the traditions of farmers in the Levant will notice the impact of these ethics in the blessing of their crops and land and will realize their complete absence in modern agricultural systems today. In our villages in the past, farmers used to see the land as an offering and that generosity of soul brings blessing. The farmer used to leave some of his crops in the land for birds, animals and passersby to eat.

People used to rush to help each other with sowing, harvesting, or other things. They were all content with their own sufficiency and were not concerned with material gain. Today, however, land is a property for trade or investment, and the logic of the market rules and is dominated by fear, caution, and greed. Farmers strive to control costs and cover losses. Birds and animals are killed by poisoning so that they do not eat the crops.

The farms are fenced so that passersby cannot approach them. Work on the land is only for a wage, and increasing profits is the concern of every landowner. Today is so far from yesterday.

Figure 1 : Agricultural lands and olive farms in northern Jordan,

Figure source: Tayoun Research Studio.

Another example of the importance of permaculture is the concept of Earth Overshoot Day, an indicator of how much humankind is consuming natural resources versus how those resources are being replenished each year. This indicator currently shows that humanity is spending its resource balance in August, and then starting to consume what is no longer available in a sustainable manner. This is like spending your entire month's salary ten days before the end of the month and then borrowing with no hope of repayment. This is because current systems are no longer sustainable in the strict sense of the word. A sustainable system is defined as one that produces more energy and resources than it needs to be built, operated and maintained, with enough surplus production to regenerate its parts over its expected lifetime. The definition may seem a bit complicated. But it is easy to understand if we consider God's balanced creation.

For example, the forest is a sustainable natural system, as we define it, in which materials and energy are renewed through photosynthesis, forming new leaves that fall to the soil and decompose. Some of these leaves feed living organisms, which in turn die and decompose to return to the soil, and the plants absorb these materials to produce more leaves and trees.

In agricultural land that is plowed annually, we find that it exhausts its stock of materials and fertility that are progressively transferred out of the system, then its productivity stops and the land perishes. This is an unsustainable system.

Before modernity, humans sought to design and create sustainable production systems, and only a few remain today, including the floating garden system (Chinampas) in the Valley of Mexico, and the sustainable aquaculture systems of Hawaii. If we compare the floating garden system to a commercial agricultural field in terms of soil fertility, for example, we find that in the floating garden system, the basins are planted with successive crops of up to seven harvests per year, without the need to rest the soil and without affecting its fertility.

On the contrary, the soil fertility is continuously increased by collecting organic sediments from the bottoms of the water channels surrounding the floating gardens and adding them as fertilizers to the soil in the agricultural basins, including duck waste, fish waste, and marine plants, in addition to many other sustainable practices. While we see that in the commercial agricultural field, the farmer needs to rest the land without planting for a season or more to restore the soil's health and ability to produce.

However, we see that soil fertility is in continuous decline as a result of the depletion of organic matter, repeated deep plowing, the use of chemical fertilizers and pesticides, and poor land management, which leads to the erosion of the surface soil, a decrease in field productivity, and the degradation of the land year after year. This is an unsustainable system.

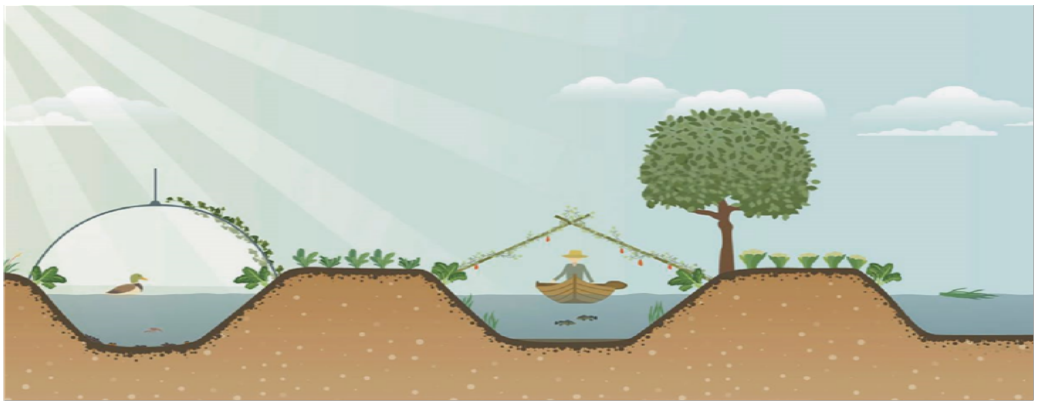


Figure 2: A drawing showing a floating garden system that combines crop and fruit tree cultivation with fish and duck farming in a sustainable manner.

Source of the figure: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 13.62

The goal is to create sustainable systems in which resources are managed wisely. This is not achieved without prior planning, but rather the result of conscious design decisions. Returning to the definition of permaculture that we mentioned earlier, we see it as an ethical design science, and design is that conscious process that begins with forming a comprehensive and holistic understanding of a need or problem, seeking to solve it by collecting and forming useful relationships between available resources and environmental elements. It is essentially a kind of future planning and good resource management.

The design process may be a complete system or parts of a system. The design may mean something tangible, such as a home garden that aims to solve the problem of water scarcity by harvesting rooftop water, or something intangible, such as a strategy or plan for managing available resources, such as recycling this collected water from the roof of the house into a fish pond and then pumping water enriched with fish waste into the garden to increase the crop, making the system more sustainable.

Design principles

Permaculture founders Bill Mollison and David Holmgren have developed two sets of design principles, which are the guidelines, and markers that a designer uses to create the most sustainable design possible. Mollison offers five general principles, while Holmgren details twelve design principles, some of which we will discuss below.

Mollison's Five Principles

1- Working with nature, not against it. A fundamental principle of sustainable agriculture is to invest time in observation, analysis and planning before designing and changing the system and environment. Permaculture looks at the elements - plants, animals and infrastructure - with a specific examination of their characteristics, functions, needs, outputs and relationships with others. This principle calls for a comprehensive and deep understanding of nature's systems, as they are the first teacher. It also emphasizes the importance of deliberation to realize their complexities, interconnections, and delicate balance. For example, a farmer may use a certain pesticide to harm the crops, but the problem quickly worsens. When the system is understood as a whole, it becomes clear that this insect controls another, more deadly insect. Uncovering these relationships enlightens the decision.

2- The problem is the solution. There is a saying in permaculture that there are no weeds. Only beneficial plants in unwanted places. These weeds help in loosening the soil and increasing its fertility, but ignorance of their properties wastes our opportunities to exploit them. Most elements have a positive side and regenerative functions if we discover them. The key to the solution lies in avoiding the rush to frame the problem as it appears at first, and taking the time to analyze its elements and realize the potential positive opportunities that can be exploited and employed in designing the system.

3- Making the smallest intervention for the greatest benefit. For example, when determining the location of a water dam, we consider choosing the appropriate location along the flow line that helps collect the largest amount of water by building the shortest possible wall.

4- The theoretical return from any system is unlimited. The potential of the system is that it can produce countless diverse crops and products. The limitation lies in only two factors: the knowledge base and the creativity of the designer.
5- Every living being has a role. All living beings around us have an impact on their environment and interact with it in their own way. These roles can be identified and its use in design.

Holmgren's Twelve Principles

1- Observe, reflect, and then act.
2- Collecting and storing available energy and resources, such as solar energy, water resources, etc. When it rains, for example, rainwater flows from the top of the hills, rushing towards the valleys or the sea, mixing with polluted flood water or salty sea water, thus wasting the opportunity to exploit it.

Here, permaculture calls for slowing down the speed of passage and exit of this resource from the system. It seeks ways to lengthen its path, distribute, collect and store it for later use, through water harvesting interventions, canals, ponds, etc. As the number of stages and the length of the path increase, the benefit from the resource increases.

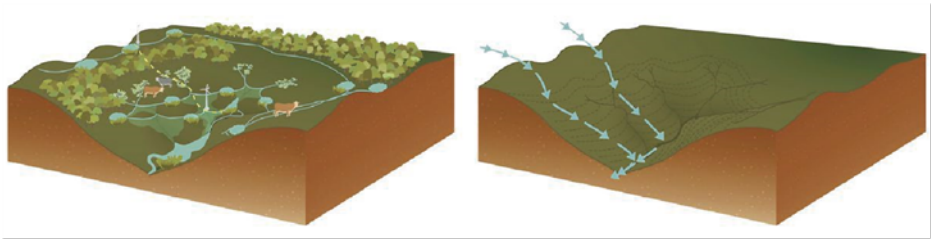


Figure 3: A drawing illustrating the principle of collecting and storing energy in a comparison between not exploiting rainwater (right) and exploiting it in the ground (left).

Figure source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 2.5

3- Obtaining a return from crops, products and other benefits and outputs.
4- Self-accountability and accepting self-criticism and criticism from others about the design and results of work to improve the system.
5- Use renewable energy and natural resources effectively.

6- Not producing waste and trying to reuse and recycle resources within the system as much as possible.
7- Design from the whole to the part and from the comprehensive picture to the details.
8- Search for ways to cooperate, combine and integrate elements and avoid division.
9- Start slowly with small steps and gradually expand with little and small solutions.
10- Appreciating diversity, exploiting it and employing it by researching the positives of each element and its relationships with other elements.
11- Blessings are in the edges and intersections, and the importance of exploiting the diversity of opportunities and biological richness at the points of convergence of the various elements and in the border areas of ecosystems.
12- Interacting with changes positively and creatively, as change is an inevitable reality and is an important opportunity for advancement and improvement.

Figure 4: The Three Ethics of Sustainable Agriculture.

Figure source 4 Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition) Module 1.1

Comparing permaculture and industrial western agricultural systems

The graph shows the difference between a farm following industrial Western farming systems and its condition eight years after adopting permaculture systems. The comparison covers several aspects, including fuel consumption measured in calories, for

example, which includes the fuel used for farm machinery and the fuel needed to produce chemical fertilizers and pesticides.

It turns out that industrial Western agriculture consumes 10 calories to produce one calorie, while permaculture systems produce 120 calories for every calorie consumed.

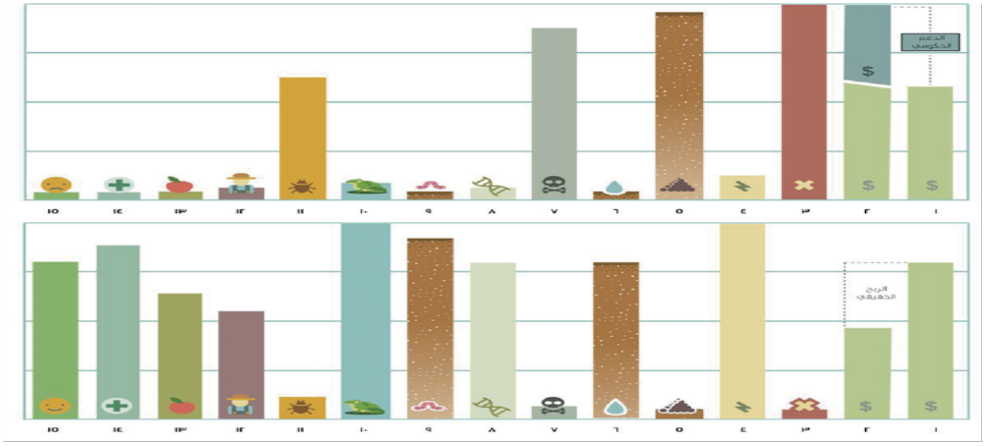
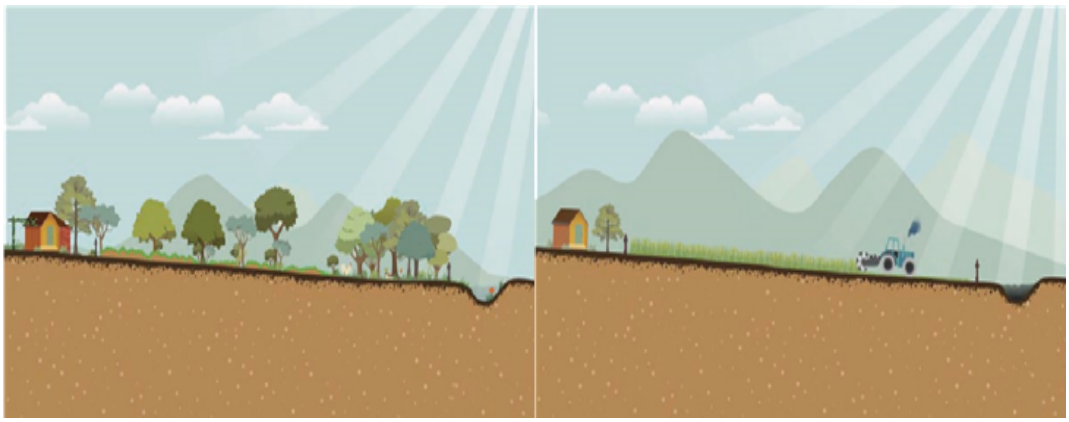


Figure (0) shows a graph comparing a farm that follows industrial Western agricultural systems (top) with its condition after adopting permaculture systems (bottom).

Figure source -Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 1.1

- Profit from farm products
- Actual costs without government support
- Fuel consumption (measured in calories) -Energy produced on the farm -Loss of soil, organic and mineral content.
- Water use and storage
- Environmental pollution of air, soil and water
- Biodiversity in plant and animal agriculture
- Life in the soil as a whole and diversity
- Biodiversity of wildlife and forests
- Pest problems and crop loss
- Labor to machinery ratio
- Nutritional value of products
- Health of the work environment
- Happiness and job satisfaction



Industrial agriculture model

- A fragile system that consumes more than it produces and its fertility decreases every year. The only product is annual field crops
- A single crop is vulnerable to pest risks or low market price
- A system that is vulnerable to drought, floods and unpredictable climate changes
- Depends on additional water sources for irrigation and continued production
- Low biodiversity
- Causes air, soil and water pollution and harms human and organism health

Permaculture Model

- A robust, well-established system that produces more than it consumes and its fertility increases every year
- Products are diverse, including annuals, fruits, herbs, wood, and animals. Multiple crops provide insurance against market changes and pests
- A flexible system protected from risks and changes
- Depends on rainwater and the moisture stored by plants and soil
- Strong biodiversity
- Improves air, soil, and water quality and benefits human and organism health

Figure 6: A diagram showing the transformation of a farm from industrial Western farming systems (top) to permaculture systems (bottom).

Figure source -Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 1.1-1.5

The following images show the transformation of different sites to permaculture systems and the impact this has had on their prosperity.

Figure No. 7: The location of the Jordanian Society for Quality Environment in the Northern Jordan Valley region in Jordan before and after the application of permaculture systems.

Figure source- www.greeningthedesertproject.org :

Figure No. 8: Pictures of the project to rehabilitate the Chinese Lewis Plateau and show the impact of permaculture systems on revitalizing the land and developing the environmental and economic region.

Figure source- The Environmental Media Project & John D. Liu

Chapter Two

Permaculture Systems Design

General Design Guidelines

This is to clarify and facilitate understanding of the principles of permaculture design, some general rules and principles that govern practical decisions and the nature of interaction with the elements of any system.

. Multi-functionality

Each element in its place performs at least three functions. For example, if we put chickens in a glass incubator, separating them from the germination area with a net, it will have an effect on increasing the room temperature and controlling insects. In addition, the chickens benefit from feeding on seed residues and weeding.

Figure 9 shows several examples of chicken functions in various contexts and the multiplicity of these functions as a result of multiple interactions.

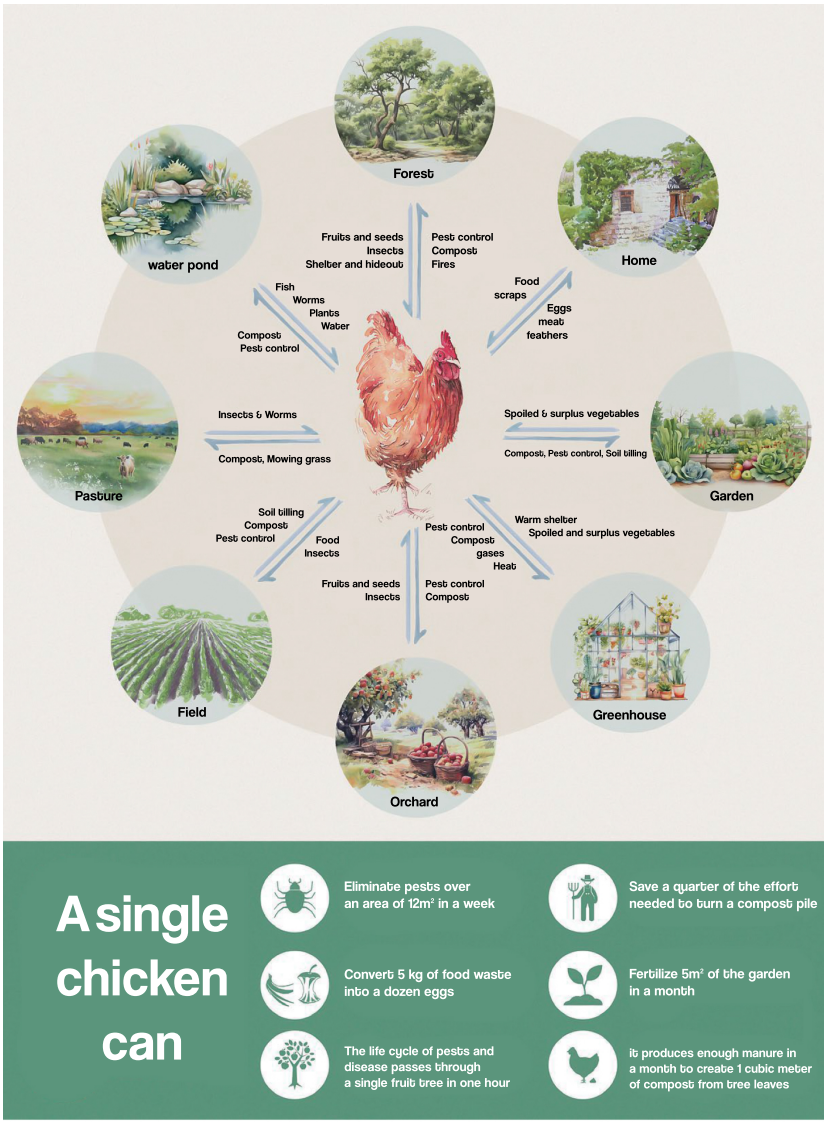


Figure No. (9): The multiple functions of chickens and explaining some of them in different contexts and places and how to benefit from them in designing permaculture systems.

Figure source: Tayoun Research Studio, based on information and facts shared by many chicken farmers within permaculture systems

House - forest - a pool of water – garden - greenhouse - orchard - field - pasture

One chicken can

- Save a quarter of the effort required to turn the compost
- Fertilize five square meters of garden in a month
- Produce enough manure in a month to produce 1 square meter of compost from tree leaves
- Get rid of pests and insects for an area of 12 square meters
- Convert 5 kilograms of food waste into eggs
- Sever the life cycle of pests and diseases for one fruit tree in an hour

. Multiplicity of elements

Multiplicity of elements that provide each basic function. For example, the farm has multiple sources of irrigation water from rain harvesting, a well, recycled gray water, etc.

. Diversity

Diversity based on positive relationships between elements leads to stability, increases production, and reduces risks.

- Recycling energy and resources

Whenever possible, the resources used in the system should be recycled as many times as possible. For example, food waste is given to chickens, which produce eggs that humans eat, and then human waste is converted into poplar tree fertilizer that is fed to goats that humans eat, and so on.

Terms and Reference Ideas in Permaculture Design--

Here we explain some basic terms related to permaculture design:

. **Resources**

Resources are all the elements and energy that surround us, and they form parts of the system. When we know them and recognize their properties, we can make the best use of them without causing harm to the environment or others. It is also important to know

that resources have several types that affect our interaction with them in terms of use, abandonment, or rationing consumption, and they are:

1-Resources that increase through modest use, such as grazing shrubs and information.

2-Resources that are not affected by use, such as solar or wind energy.

3-Resources that disappear or decompose if not used, such as crops and fallen trees.

4-Resources that diminish through use, such as mud deposits, fish stocks, and coal.

5- Resources that destroy other resources if used, such as toxins and radioactive materials.

It is worth noting that pollution, whatever its type, is the increase and accumulation of a resource that exceeds the system's ability to employ it. For example, piles of chicken manure may lead to water and air pollution if they accumulate, while useful fertilizers can be made from them if they are available in reasonable quantities. Therefore, the basis and requirement when talking about resources is the principle of sufficiency.

.

-Yield or return

It is the energy or surplus product of the resources available in the system after fulfilling what the system needs to continue. The yield has various and numerous forms and its scope is broader than the yield measured by weight of vegetables and fruits, as it includes the health of the land and building up its water reserves, and includes the health of people and happiness at work and the pleasure of looking at a beautiful garden, or forming deeper relationships with the surrounding environment and neighbors. It is also the product of knowledge, experience, food security and other crops. Permaculture does not focus on a specific type of crop or yield, but always aims to increase the yield in its various forms, and to preserve and store it.

- Order and Chaos

The observer of the nature notices the perfect order in God's creation, in the composition of things living or otherwise, in their interactions, the overlapping of their functions and the complexity and interdependence of their relationships in harmony, interconnection and delicate balance. However, humans still fail to develop effective systems such as those we find in nature, and we often see them reduce the design process to attempts at visual arrangement of objects without forming deep positive relationships that achieve interconnection and balance between them.

Permaculture sees that the system in its deepest sense cannot be simplified to the apparent arrangement of things. What is arranged in form may lack the slightest degree of organization in its relations with the environment or its effectiveness in performance. The simulation of complex systems in nature is through the organization of the parts, their intersections, their relations and their functions with knowledge and wisdom in a way that achieves the desired goal and benefit from them, even if they appear to the observer to be disorganized.

-Diversity and stability

Diversity in general is achieved by increasing the number and type of system elements. However, diversity does not guarantee stability in itself and may cause destructive chaos. Stability is achieved by developing the highest number of positive cooperative relationships between the elements.

The role of the designer is to interpret these relationships and ensure their sustainability in a way that serves the interest of all.

Vertical overlay.

Permaculture aims to exploit productive systems to their maximum potential, through multiple and overlapping functions in one place and one time. An example of this is the multiple layers of productive plants that can be grown in an orchard, or what is called in permaculture the food forest. In this system, plants are grown in layers that overlap in space and time, intensively, with the aim of exchanging functions and benefits, accelerating growth, reducing the need for work, increasing productivity, and other benefits. The first of these layers (1) is the layer of root plants, such as onions, garlic, and carrots, followed by (2) the layer of grassy ground cover such as purslane or

fenugreek. (3) the layer of herbaceous plants such as wheat, legumes, corn and vegetables. (4) the layer of woody shrubs such as Rosemary and Brambles. (5) the layer of small trees such as almonds, citrus fruits and olives. (6) the layer of large, tall trees such as mulberry, carob and date palms. Finally (7) the layer of climbing plants such as grapes. This overlay is designed by forming positive relationships between its parts and integrated alliances between them to achieve diversity and stability.

Figure 10: Example of vertical overlay in a food forest design illustrating the overlay of different strata and functions in a high-density, high-productivity system.

Source of the figure: Discover Permaculture with Geoff Lawton, 'The Forested Garden' video –

1- Rooted plants layer

2- Herbaceous ground cover layer

3- Herbaceous plant layer

4-Woody shrub layer

5- Small trees layer

6- Large tall trees layer

7- Climbing plants layer

Design Methods and Steps

Permaculture follows several different methods and steps for design that depend on the designer's vision and analysis, the site circumstances, and the characteristics of the elements. Below are some common methods for designing permaculture systems, followed by an example of the sequence of steps to reach the design.

. Observation and reflection
. Element analysis
. Choices and decision
. Accumulation of information
. Human flow diagram
. Area and sector analysis
. Lessons from nature (simulation)
. Random arrangement

Step1: Conscious contemplation and observation, then exploration, research and information gathering - The design process begins with defining the goals, endeavors and what we want to achieve in a site, followed by analyzing and listing the available resources, needs and problems, then collecting observations by taking notes and taking pictures or video with an audio explanation of what we notice and monitor on the site or during research.

Amongst the information the designer needs to collect is weather conditions and patterns such as the rate and maximum and minimum precipitation, as well as average, maximum and minimum temperatures. Knowledge of this and similar information leads to a design that endures extreme events of drought, flooding and others, producing a sustainable system that is resilient to shocks and changes.

Step 2: Draw a realistic (standard) plan for the site with a sector analysis of the surrounding environment. Later, a basic plan is drawn that shows the elements on the site as they are in reality in terms of number, area and location - from fences, lighting poles, water and electricity sources, entrances, paths, roads, buildings on the site, trees, water bodies, etc., and clarifies all intangible information, such as its regulatory boundaries and the laws governing them, such as side setbacks. It also includes contour lines that express the topography of the land and the shape of its terrain, and other

elements that will later affect design decisions. As for the layer of sector analysis of the surrounding environment, it displays external influences such as the angle of the sun in summer and winter, the direction of the prevailing winds, sources of odors, or the direction of the fire threat, etc.

Step Three: Selecting System Elements

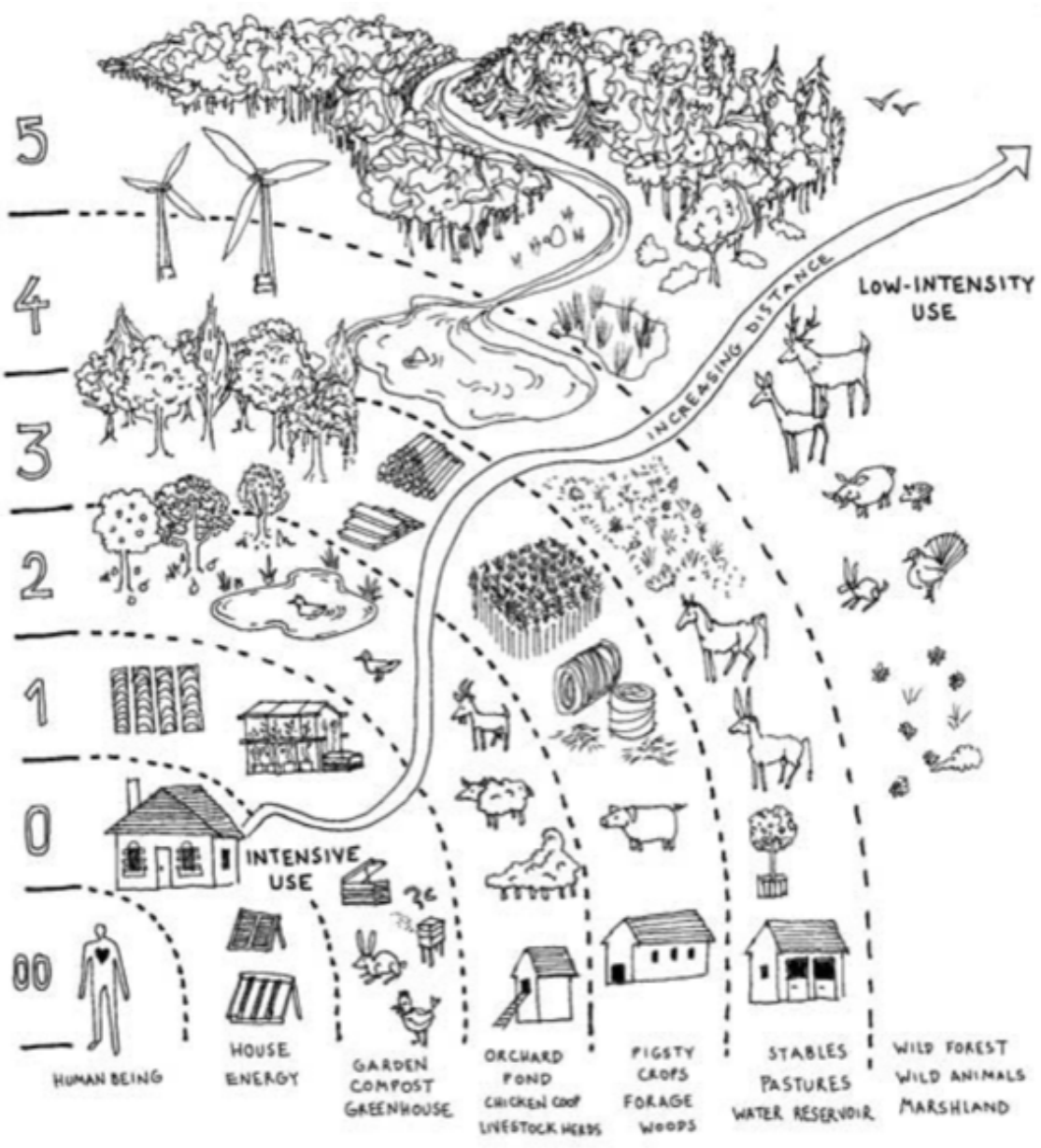
After listing the available resources and elements present on the site that appear on the actual site plan, the elements that the designer wishes to include in the system in the future are determined, including plants, trees, animals, buildings, and other activities and elements.

Zones:

Figure No. (11) [overpage] An illustration showing an example of the regional design and arrangement of elements for a farm in zones from 1 to 5.

Source of the figure :www.newsociety.com/Blog: Using Zone 00 to Transform Your Inner Landscape

Zone number is inversely proportional to the number of visitations needed to maintain the elements in that area. The greater the management required, the closer these elements are placed to the central element or zone, which is usually the dwelling place.



0 - Home - Solar heater

1 - Garden - Fertilizer making - Nursery

2 - Chicken house – Orchard - Water pond

3 - Field crops - Wood trees – Livestock

4 - Pasture stables - Water storage

5 – Forest - Wild plants

Long Distance = Spaced Visits

Near Distance = Elements that need to be followed closely

Chapter 3

Permaculture in dry areas

Permaculture, as the previous chapters have explained, is an ecological design system, where the designer bases his decisions on arranging the design elements after studying the surrounding environmental patterns and data. The more the designer increases his knowledge of the elements and their relationships and the more skilled and imaginative he is, the more the system produced should be consistent and harmonious with its environment, taking advantage of the available opportunities, avoiding the latent risks, and becoming more sustainable.

Weather factors are one of the most important factors influencing design decisions in permaculture systems. Each geographic region is characterized by recurring weather patterns and climatic conditions in the form of one or more annual weather cycles. These are opportunities and challenges specific to each region. For example, in an area with high rainfall and clay soils, the optimal solution for water storage may be ponds and small clay dams. This solution is not suitable in an area with scarce rainfall and highly permeable sandy soil. The basis of design decisions is knowledge of these conditions to arrive at the optimal solution that mimics nature and embodies the wisdom of our ancestors in seeking to build sustainable systems.

Scientists have divided and classified the world's regions according to the prevailing weather factors, to facilitate their study and description, into dry regions, humid regions, tropical regions, and others. Each of them is characterized by a number of fixed characteristics such as temperature range, rainfall rates and distribution, seasons, humidity, and others. Regions of the same classification may share similar types of plants and animals or aspects of the cultures of the peoples who inhabit them, such as the form and materials of the dwelling, and methods of cultivation, food preparation, clothing and popular culture, as regions may share similar challenges and opportunities with their climate counterparts. For example, a desert area with saline soil and annual rainfall not exceeding 70 mm in the UAE may have many similar characteristics to a

region in Iran or India in terms of vegetation cover, types of crops and methods of managing limited water resources.

Knowledge of weather factors is essential for the designer of permaculture systems, and it is a broad topic that we will not elaborate on in detail in order to discuss dry areas. Those interested in the subject can read Bill Mollison's book (Permaculture: A Designers' Manual), which contains chapters in which he discusses the different weather zones and their design solutions through his study of the environment and local cultures of each.

What are dry areas? Definition and characteristics

Arid and semi-arid areas are generally defined as those that are predominantly dry and have annual precipitation rates of 0 to 400 mm/cm2 - this includes rain, fog condensation and the vapors produced by plants that condense and fall on the soil. These areas share similar conditions, challenges and opportunities, some of which are mentioned below:

- The soil is generally alkaline, reaching 8-9 on the pH scale. In saline basin areas, it reaches pH 10-11. The soil can become productive when the alkalinity is adjusted and the acidity is increased, which helps release essential mineral elements for plant growth and vital processes. High alkalinity causes stunted growth of plants and general weakness that makes them susceptible to pests due to deficiency of zinc, iron, copper and manganese. The soil basin can be adjusted by spraying sulfur or its compounds with the missing elements.

- The spread of sandy soil with high salinity, one of the challenges of which is its high permeability to water. Possible solutions include adding humus or clay amendments (bentonite) to the soil, in addition to collecting rainwater in horizontal water ditches and raised agricultural basins with edges, as shown in Figure 13, page 31.

- When trees are present, transpiration increases and evaporation decreases, which keeps salts away from the soil surface. On the other hand, when there is no vegetation cover, the capillary action in the soil raises salts to the surface (from compounds of magnesium, calcium and phosphate), which increases the salinity of the soil to a point where plants cannot grow.

- The sensitivity and fragility of this system requires adopting a strategy of working with small experiments that are gradually expanded upon with their success. To compensate for the materials that are not available in the soil, palm remains, organic waste, and bird droppings can be used as a source of phosphate and various minerals. Care must be taken not to add too much nitrogen to the soil, which leads to the plant burning due to the strong heat and sun.

- In dry lands, the risk of using chemical fertilizers and pesticides is compounded by the lack of moisture and water, which slows the decomposition of these chemicals and leads to their leakage and concentration in the water bodies on which farmers and locals depend.

- Continuous erosion occurs due to wind, but rain, despite its scarcity, is the main erosion feature in the valleys due to its associated flood events.

- Much of the falling water often ends up collecting in salt ponds due to rapid evaporation:

- Dry land plants produce abundant seeds with long shelf life, most of which are spread by wind.

- The conditions for germination and emergence of plant forms are rare and may occur once every 7-20 years.

- Ants are more effective in aerating the soil and breaking down and decomposing organic matter in dry areas compared to worms, which perform these functions in more humid areas.

- Animals hide in burrows in search of shade and are active at night to conserve water in their bodies.

Figure 12:

Erosion, soil drift, scarcity of rainfall, and the decline or disappearance of vegetation cover are among the challenges facing dry areas.

Source of the figure: Tayoun Research Studio, and the images show dry areas in southern and northern Jordan.

Design strategies in dry areas

Design strategies in dry areas focus on responding to the main challenges of these areas, such as scarcity of rainfall, high evaporation rates, high temperatures, and poor and salinized soils, through various interventions that activate the use of rainwater, reduce evaporation, improve the local climate, and increase soil fertility. The following are some reference frameworks for design and management of water resources, soil, and crops in dry areas.

Water: The main focus is on storing as much water as possible in the soil and reducing evaporation. Water harvesting interventions in dry areas aim to not waste any water, and vary according to the slope of the land and the type of soil. Interventions include silt collection fields behind stone walls, and water injection pits filled with organic matter and crop residues. All of them adhere to the strategy of reducing the surface area of water. Interventions also include recycling grey water (from the kitchen or sink) and reusing it in agricultural basins. At the level of watersheds, we slow down the running water and then distribute it by transporting it across open land in horizontal and semi-horizontal channels and then allowing it to penetrate the soil. Water can be slowed down and distributed using tree lines that are located at the same level (contour line). Or deep ploughing lines that are located on one level (contour ridges), or lines of stones and natural rock barriers on one level (contour stone ridges and stone crescents) that wash the salt from the soil and feed the saline groundwater layers with fresh water. The design takes into account reducing evaporation by providing windbreaks, using subsurface irrigation systems, covering the soil with mulch, etc.

Soil: The focus is mainly on reviving dead soil by building soil biology from plants, animals, and microscopic organisms such as bacteria, fungi, and others, which help provide the elements that plants need and neutralize the problem of soil dryness and salinity. Soil interventions include stopping destructive human interventions such as repeated tillage, weeding, burning and overgrazing, providing the moisture and aeration that living soil needs, building loose soil with open, uncompact pores and providing decomposed organic matter that is food for microorganisms. Nature’s recovery and the formation of living soil can be accelerated by adding compost or aerated manure rich in microorganisms – which we will explain later on how it works.

Planting: Agricultural systems and productive gardens in dry areas focus on increasing the system's resilience against environmental stresses such as drought and high temperatures, through the diversification of drought-resistant crops and trees. Intensive agricultural systems such as ecological agriculture and food forests are adopted, in addition to integrating trees

and Native shrubs in the system, whether as windbreaks, tall shade trees that improve the local climate and reduce evaporation, nitrogen-fixing plants, or fast-growing trees that provide organic matter to build and cover the soil.

Food Forests and Agriculture

Figure 13: Examples of permaculture interventions in drylands for water systems, soil structure and planting.

Figure Source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition) + Facebook Posts:

From top left, to right.

1- Reuse of grey water

2- Capillary irrigation basins

3- Irrigation by seepage from clay pots

4- Flat agricultural terraces

5- Single level water ditches

6- Trench farming

7- Raised agricultural basins

8- Grid and crescent system

9- Covering the soil with natural bedding

10- Use of arbors

11-Keyhole Garden

12- Food forests and shade tree planting

Single-level water ditches

Challenge/Opportunity (Why):

Soil absorbs less than 12% of the water falling on its surface, while the rest is enriched and transformed into an unusable resource that evaporates, mixes with salty or polluted water, or leaves the site, and the opportunity to exploit it is lost. This loss is accompanied by other factors such as the deviation and loss of topsoil, dispersion of organic content, and loss of site fertility.

Solution/Intended Benefit (What)

The solution starts with understanding the topographic nature of the site and determining the slope of the land. If the slope of the land does not exceed 12%, we start planning to dig water trenches at one level (contours), which are channels that help slow down the water running on the surface, distribute it and store it in the soil to raise the moisture level and replenish the groundwater reserve. These channels are considered tree planting systems. It harvests the silt and organic matter flowing on the surface of the soil to support rain-fed tree crops in the long term. We call it contour, meaning that the level of its edges and the water level in it when full are at the same vertical height (shaqla), so there is no water flowing inside it, but rather it settles and penetrates the soil.

Technical details (how):

- The distance between one water trench and another varies according to the slope of the land. A distance of 12 linear meters can be adopted for flat land in a dry area. In sloping areas, the distance between two trenches depends on the length of fully grown trees so that the level of the bottom of the tree trunk in the upper trench is parallel to the top of the tree crown in the lower trench.

- The areas between two water trenches can be exploited in more than one way and field crops and food forests succeed in them.

- The location of the water trench is planned by finding the contour points of the same level using engineering surveying tools and can be replaced by simple tools such as the hose level (Shaqla) or the frame level (A-Frame).

- Excavation can be done manually or by using heavy machinery, where the trench soil is excavated and the excavated soil is dumped on the lower side of the trench to form the mound that confines the water. Surplus water is discharged over a flat sill area either away from the site, or to another holding point.

- Trees can be planted on the sides of the trench or below the trench in dry areas to take advantage of the scarce rainfall, by harvesting the infiltrated water.

- The dimensions of the trench vary depending on the amount of rainfall, the slope of the land, and the nature of the soil. In clay soils, the depth is greater and the width is less, and the opposite is true in sandy soils. You can start with a small depth (about 40 cm) and a width of one meter, then expand with experimentation.

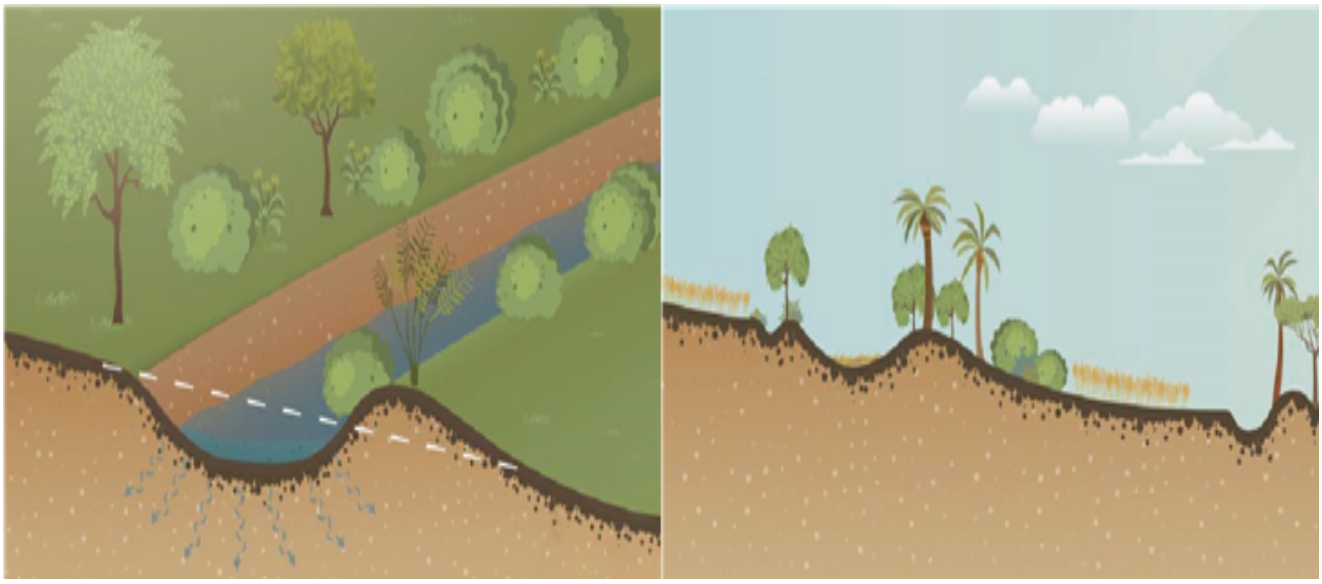


Figure 14: A cross-sectional drawing of a single-level ditch as a rainwater harvesting and rainfed tree planting system.

Source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 7.36 + 11c.13

Submersible Tanks

Challenge/Opportunity (Why):

Farmers lose a large amount of water due to evaporation, and with repeated evaporation, soil salinity increases. Drought also leads to the deterioration of soil micro-life, accompanied by many plant diseases and increased attraction of pests.

Solution/Intended Benefit (What)

The surface level of the submerged agricultural basins is lower than the surrounding side paths as shown in Figure 15. This technique allows for increasing the soil's ability to retain water. It also reduces evaporation by reducing the visible area exposed to warm winds that dry the soil quickly if the agricultural basins are elevated above the soil surface. These basins can be waterproofed by adding a clay material such as bentonite or using a plastic barrier before returning the soil to the trench during preparation. This intervention is only necessary if the soil is very saline or in the case of sandy soils that do not retain water.

Technical details (how)

-In a home garden or as an agricultural system, the planting bed should be 120 cm wide and the surrounding paths should be 60 cm wide. The width of the path allows the passage of a material transport vehicle, and the width of the basin allows access to the central area of the basin when standing in the path without having to step inside the planting bed.

-When preparing the submersible basins, you can start by drawing the shape of the basin on the soil using pegs, strings or dry lime. Then, remove the surface soil rich in humus, if any, and dig the soil to a depth of 30-60 cm, then add compost, humus and biochar, return the soil and cover the trench after adding the waterproofing if necessary.

-After returning the treated soil, a layer of compost 5 cm thick or more is added, then a drip irrigation network or other irrigation methods for dry areas is installed, followed by adding a thick layer of organic mulch (straw or other).

-Leguminous plants such as creeping -white clover- are sown as ground cover nitrogen fixers, which can be kept as an additional means of crowding out unwanted weeds and fixing nitrogen in the soil in preparation for planting and as a natural living mulch that conserves soil moisture.

-It is forbidden to compact and press the soil, so zero-tillage farming methods are followed, and they are replaced for the purpose of loosening and aerating the soil by using a wide fork tool to loosen the soil without turning it over after each agricultural season.

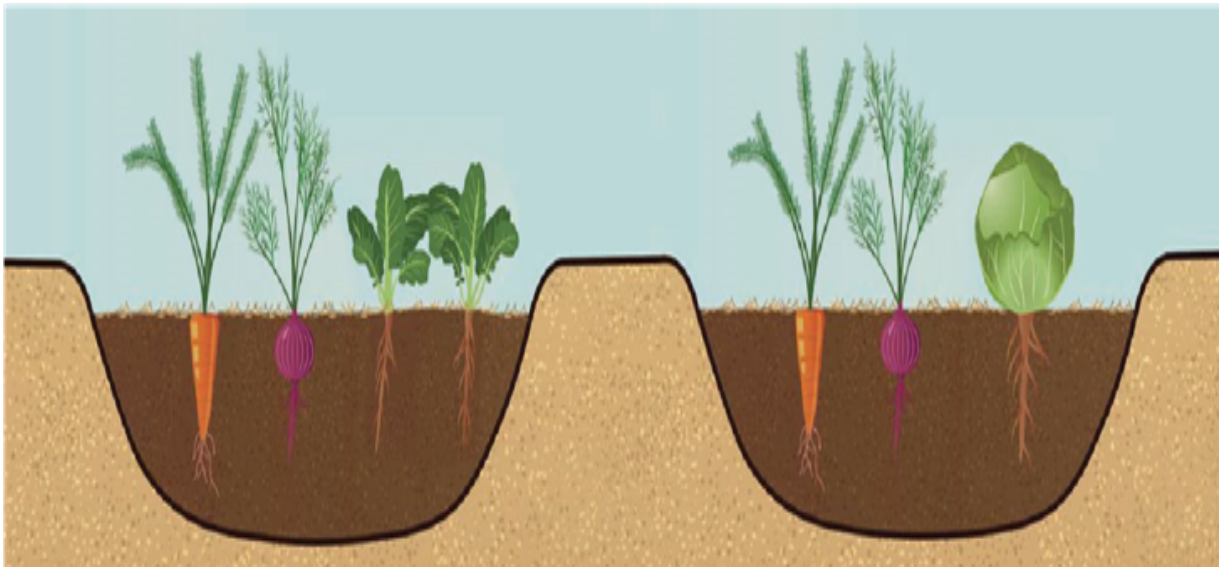


Figure 15:

Drawing of a submersible vegetable pond system.

Source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 10.8

Hot Air Composting

Challenge/Opportunity (Why)

The production of our food depends on the plant's ability to absorb and analyze elements and minerals from the soil and convert them into organic compounds that represent the sum of leaves, fruits, and various parts of the plant. The effectiveness of plants in carrying out this process depends on a complex and interconnected biological system, the basis of which is microorganisms of various types, including bacteria, aerosols, and other microscopic organisms. The microscopic life of the soil is directly responsible for converting nutrients from a form that is not available to the plant to a form that the plant can absorb and benefit from in its vital processes. Nitrogen, for example, is available in its gaseous form in the air in large quantities, but it is not available to many plants. Beneficial nitrogen-fixing bacteria supply it to the plant in its hairy roots. In contrast, modern agriculture attempts to compensate for the selection of this cycle - due to repeated plowing and killing of microorganisms - not to solve the root of the problem, but to add salt compounds containing nitrogen, which negatively affects the environment, soil and humans.

Solution/Intended Benefit (What):

At the University of Berkeley in the United States, a system has been developed to multiply microorganisms that are effective in helping plants access the minerals and materials they need to perform vital processes and grow. When following this system, you only need 18 days to convert various organic wastes into at least a cubic meter of compost.

It is essential that the system is aerated, so the pile is turned for the first time 4 days after it has been formed and then once every two days until the desired result is reached after approximately 18 days. Thus, we maintain an aerobic environment that encourages aerobic organisms to grow and eliminates harmful and pathogenic anaerobes. We also moisten the pile to maintain a suitable environment for the growth of these organisms. This method is called hot composting because the temperature of the pile on the fourth day is between 55-60 degrees Celsius.

Technical details (how)

The compost pile consists of three components and water is added to it for moistening, with the brown, green and black materials being one-third each. The brown materials include dry organic materials such as straw, wood shavings, paper, cardboard, cotton cloth and other carbon materials. As for the green materials, Moist organic matter includes food scraps, agricultural waste, green grass, tree prunings, and other materials high in nitrogen, while black matter includes various types of animal manure.

-The location for the compost pile is chosen so that the area is well drained, relatively protected from wind and sun, and has sufficient space to make and turn the pile. Layers of the three components are stacked, and loosened, starting with a quantity of brown material at the base to allow air to pass through and prevent an anaerobic environment under the pile.

-When turning, remove the outer layer and place it in the middle of the second pile after turning, then sprinkle the more decomposed inner layer over the first layer.

- We need to test the humidity, temperature and ventilation of the pile continuously to ensure the availability of suitable conditions for microorganisms during the period of making the compost.

- We measure the temperature on the fourth day using a thermometer in the middle of the pile, and it should be between 55-60 degrees Celsius for best results.

- If a thermometer is not available, you can stick your arm inside the pile for ten seconds. If you can't, the temperature is too high. If we stop at 10 seconds as the tolerance limit, the temperature is suitable. It also shows us if the pile is cold.

- If the temperature is low with sufficient moisture, we increase the amount of green or black materials when turning and nitrogen increases the temperature. If the temperature is higher than required, we add carbon-based materials when turning to lower the temperature.

-The aeration test is simple. If the pile smells like rotten eggs or rotten meat after the first turn, then the decomposition is anaerobic. The solution is to spread the pile out in the sun and reshape it again. The desired smell is the smell of clean soil, ignoring the smell of manure and decomposing materials in the first period before mixing well.

-As for the humidity, it is measured by holding a handful of the mixture in the palm of the hand and squeezing it as hard as possible and looking at the amount of water that oozes out. If the amount of water is more than 10 drops, the pile needs to be dried and spread out in the sun for a while and collected again. However, if the handful is dry and not a single drop falls, we need to add water while turning. The desired result is 2-3 drops oozing at most.

-In cases where the desired result mentioned above is not achieved, after treating the problem, we add two days and change the plan.

To use compost, it can be added to the soil surface in a 5 cm layer, or in the seedling planting hole, as well as when preparing the soil by mixing it. It can also be sprayed on the leaves of plants and the root area by preparing a liquid compost infusion and using it within two hours or more of its preparation to avoid turning it into an anaerobic environment.

Figure 16: A diagram showing the components of a Berkeley hot air pool (hot compost) over 18 days.

Source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 8.15

Green materials

Moist organic matter from food scraps, agricultural waste, green weeds, tree pruning, etc.

Brown materials

Dry organic materials such as straw, wood chips or shavings, paper, cardboard, cotton clothes, etc.

Black materials

Animal dung of various types

Worm Farm

Challenge/Opportunity (Why):

Worm farms share the same goals as composting, but they don't require a lot of space, effort or time to implement, and they are a good way to dispose of food waste and turn it into healthy soil - as a fertilizer and a pest and insect control material.

Solution/Benefit (What):

In a small basin equipped with a drainage hole, a quantity of organic manure (horse/cow) is placed on a layer of wet cardboard and newspapers, then a group of special manure worms are added and food scraps are added daily. The worms' food consumption is monitored and increased or decreased as needed. The basin is covered with porous materials to allow air in and protect the basin from the sun and predators such as cats and mice. Water is added daily to maintain high humidity in the basin materials.

Technical details (how)

- Citrus and onions are excluded from food waste absolutely, and meat if there are not large numbers of worms in the tank.
- The liquid resulting from watering the tank daily can be used for root irrigation or foliar spraying, at a mixing ratio of one to 20 of liquid fertilizer to chlorine-free water. Be sure to spray away from sunlight.

When you want to harvest worm compost every three months, remove the cover from half of the tank and refrain from adding food scraps to this part until the worms migrate to the covered area where the food is. The compost is collected and used in the garden or nursery, then a new amount of layers is added, food is added and the tank is re-covered.

Figure 17 shows a drawing of the details of the worm farm, including components, materials, and assembly method, in addition to general information about how to benefit from it.

Source :Discover Permaculture with Geoff Lawton, Facebook/Instagram

Stone Bricks

Cover

Food Waste

Horse Manure - Cow

Worm Compost

Old bathtub

No Citrus & Onions

Continuous Production of Liquid Compost

Converting Manure & Food Waste into Rich Compost

2 Liters of Liquid Compost Every Day

300 Liters of Worm Compost Every 3 Months

Raised Farm Basins

Challenge/Opportunity (Why):

Raised basins are commonly used in humid areas with high rainfall due to their ability to drain water and prevent soil rot and its transformation into a harmful anaerobic environment. Their good drainage of water can be employed in areas with high salinity levels in the water, which is common in dry areas. They are also easy to maintain for those who are not experienced in agriculture.

To solve / desired benefit (what)

Agricultural basins or terraces raised above ground level compared to the surrounding paths, usually with a single level (contour), and within a home garden or vegetable farm.

Technical details (how):

- The basins or terraces are 15-30 cm higher than the height of the adjacent path.

- The planting basin should be 120 cm wide and the surrounding paths 60 cm wide to prepare the path for the material transport vehicle and to reach the middle of the basin when standing in the path without having to step inside the planting basin.

- When preparing the basins, you can start by drawing the shape of the basin on the soil using pegs, strings or dry lime. Then, remove the humus-rich topsoil, if any, and collect the soil in the form of terraces and mix it with compost, humus and biochar as needed, while leveling the surface and cleaning it of stones.

A layer of compost 5 cm or more thick is added, then a drip irrigation network or other irrigation methods are installed for dry areas, followed by adding a thick layer of organic mulch (straw or other).

- Leguminous plants such as white clover are sown as nitrogen-fixing ground cover which can be kept as an additional means of crowding out unwanted weeds and fixing nitrogen in the soil in preparation for planting and as a living natural mulch that conserves soil moisture.

- It is forbidden to compact and compress the soil, so we follow zero-tillage farming methods, and it is replaced by loosening and aerating the soil with a wide fork tool to lift the soil without turning it over after each agricultural season.

- It is possible to bury the gray water drainage pipe at a depth of 15 cm in the middle of the basin from above, as shown in the figure.

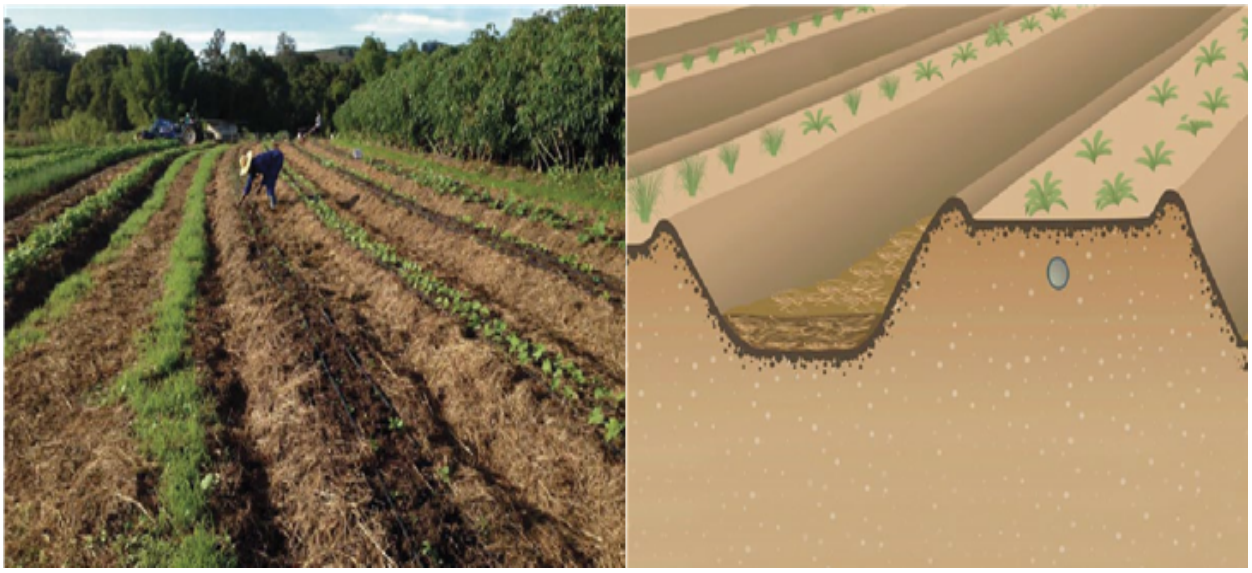


Figure 18: A drawing and photo showing details of raised beds, planting methods, and covering with natural mulch.

Source: Discover Permaculture with Geoff Lawton, PDC Full Course Content (3rd Edition), Module 116.43 + FB

Capillary irrigation basins

Challenge/Opportunity (Why)

Water is a precious natural resource and a valuable commodity in arid areas. Farmers strive to save water consumption in irrigation and protect this water from evaporation by various methods, including watering during the cool times of the day, and covering the soil with natural bedding such as straw and others. However, some of this water and moisture seeps away from the roots of plants, which necessitates the need for periodic watering in large quantities.

Solution / Intended Benefit (What)

Capital irrigation basins are water tanks topped with a layer of soil with a mechanism to raise this soil above the surface of the water such as using pebbles or stones covered with a piece of cloth. The presence of this water at the bottom in contact with the soil leads to the occurrence of the phenomenon of capillary absorption.

The water moves from the bottom to the top to reach the root zone, and the presence of water in the tank protects it from evaporation, as the surface of the water exposed to the air and evaporation is only the area of the feeding pipe. This system is used when water is scarce, and after the first filling it consumes 1-2 liters per square meter of the agricultural basin per day, which can contain 14 seedlings of various plants. It is also used in cases of cultivation on roofs of houses and balconies.

Technical details (how)

A pipe is installed to drain the excess water so that the intersection area between the soil and the water does not exceed 5 cm. This prevents the soil environment from becoming anaerobic, which is unsuitable for growing food.

Rainwater collected from the roof of any building can be directed into this system.

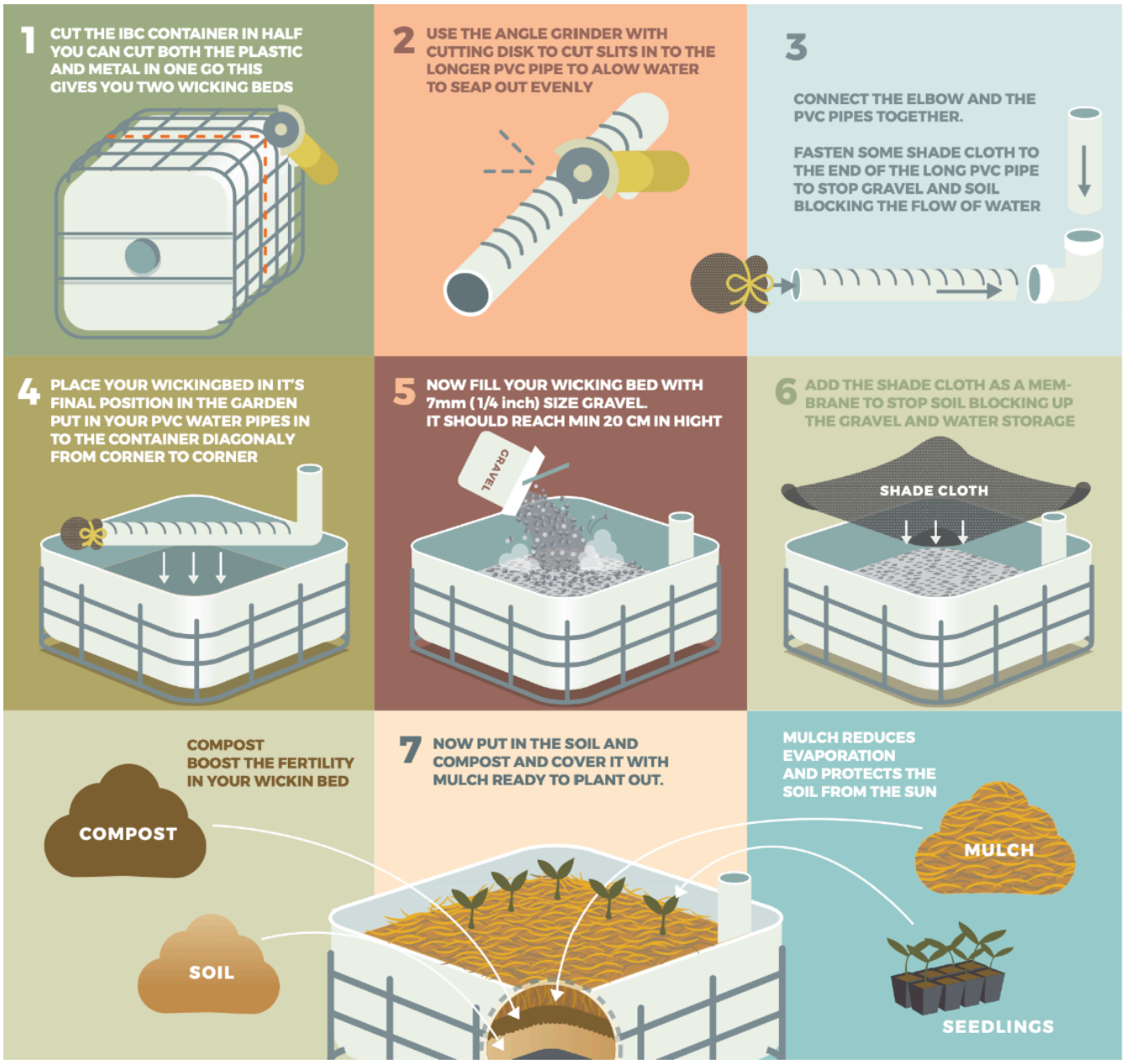
. The depth of the soil varies according to the types of plants and the depth of their roots and is most often about 40 cm.

After preparing the soil and mixing it with organic materials, a 5 cm layer of compost is added to the surface, and covered with a 10 cm layer of natural mulch (straw, cardboard) and the seedlings are initially watered until their roots extend down to the moist area.

-Requires a small amount of water to compensate
-These basins use 90% less water compared to other agricultural basins
-Ideal system for dry areas and rooftop farming
-From bottom to top to irrigate plants

Figure 19: A drawing showing the capillary irrigation system, some of its details, and the benefits of using it in dry land farming systems.

Source : Discover Permaculture with Geoff Lawton, Facebook/ Instagram Posts


1 CUT THE IBC CONTAINER IN HALF YOU CAN CUT BOTH THE PLASTIC AND METAL IN ONE GO THIS GIVES YOU TWO WICKING BEDS
2 USE THE ANGLE GRINDER WITH CUTTING DISK TO CUT SLITS IN TO THE LONGER PVC PIPE TO ALOW WATER TO SEAP OUT EVENLY
3
CONNECT THE ELBOW AND THE PVC PIPES TOGETHER.
FASTEN SOME SHADE CLOTH TO THE END OF THE LONG PVC PIPE TO STOP GRAVEL AND SOIL BLOCKING THE FLOW OF WATER
4 PLACE YOUR WICKINGBED IN IT'S FINAL POSITION IN THE GARDEN PUT IN YOUR PVC WATER PIPES IN TO THE CONTAINER DIAGONALY FROM CORNER TO CORNER
5 NOW FILL YOUR WICKING BED WITH 7mm (1/4 inch) SIZE GRAVEL. IT SHOULD REACH MIN 20 CM IN HIGHT
GRAVEL
6 ADD THE SHADE CLOTH AS A MEMBRANE TO STOP SOIL BLOCKING UP THE GRAVEL AND WATER STORAGE
SHADE CLOTH
COMPOST BOOST THE FERTILITY IN YOUR WICKIN BED
COMPOST
7 NOW PUT IN THE SOIL AND COMPOST AND COVER IT WITH MULCH READY TO PLANT OUT.
MULCH REDUCES EVAPORATION AND PROTECTS THE SOIL FROM THE SUN
MULCH
SOIL
SEEDLINGS

Pipe Gravel Shade-cloth (or geo-fab)

Soil Compost Straw-mulch Seedlings

Figure No. (20): Steps for implementing and installing a capillary irrigation system by recycling liquid transfer tanks.

Source: Discover Permaculture with Geoff Lawton, Infographic "How to Make Droughtproof Wicking Beds Using IBC Containers"

SUMMARY

This Student Workbook is part of the project "Increasing the Resilience of Both Displaced Persons and Host Communities to Climate Change-Related Water Challenges in Jordan," The project is funded by the Adaptation Fund and is being implemented by UN-Habitat Jordan, in collaboration with executing entities such as the Global Permaculture Research Institute of Australia (GPRI)."

The Student Workbook Introduces Permaculture definitions, ethics, core concepts and principles, its design process, along with a number of permaculture strategies and solutions suited for dry lands -the context of the project.

Dry lands Permaculture solutions, presented in this Student Workbook, focus on good design as a climate change mitigation measure -including water, soil and vegetation strategies. Some of the solutions presented are: Swales. a rainwater harvesting element and a tree growing system that slows, spreads and soaks water across the landscape, Increasing water availability in arid landscapes. Zooming in to the garden, a Sunken Bed is a farming technique that allows for water and soil fertility preservation and accumulation year after year. The 18-Day Hot Compost, developed by University of California, Berkeley. is the most efficient and fastest way to produce high-quality bioactive compost that is vital for soil and plant health, and is the quickest way to condition soil for better water retention and holding capacity. The Worm Farm is the least resource- and time-demanding way to revive dead soils leading to better soil and plant health merely using kitchen scraps. The Raised Beds is a way to improve soll drainage where low-quality irrigation water is used. Finishing with Wicking Beds, this low-tech system that uses 1-2 liters of water per day to grow up to 14 plants for 1m² garden area, saving up to 90% of water compared to normal garden beds.

- This guide was written and designed by Yaman Amr and Dima Assaf in collaboration with the United Nations Human Settlements Programme (UN-Habitat) and the Permaculture Research Institute (PRI) Australia, under the Adaptation Fund project: Increasing the Resilience of Displaced Persons and Host Communities to Climate Change-Related Water Challenges.

- The English translation was performed by Yousef Saidan .

- Materials and images provided by Discover Permaculture, LLC

Resilient
water solutions
against climate change
in Jordan and Lebanon

تم كتابة و تصميم هذا الدليل من قبل يمان عمرو و ديمة عساف بتعاون بين برنامج الأمم المتحدة للمستوطنات البشرية (UN-Habitat) ومعهد بحوث الزراعة المعمرة العالمي في أستراليا (PRI)، ضمن مشروع صندوق التكيف: زيادة قدرة النازحين والمجتمعات المضيفة على مواجهة تحديات المياه المرتبطة بتغير المناخ.
المواد والصور المستخدمة مقدمة من ديسكفر بيرماكلتشر، شركة ذ.م.م.Discover Permaculture

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